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US 4413881 A US 4296996 A US 3825320 A
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(54) Hermetic seal for an optic fibre

(57) A hermetic seal for a fibre optic 12 mounted onto a component 11 with an aperture 11a has a sealant 14 which acts as a boundary between two media 15,16. The sealant 14 may be made from silver chloride or silver bromide or a mixture of both. The optic fibre 12 may be bare or have a jacket 12b and may have a thin metallic layer 13 between the fibre and the sealant 14. The metallic layer 13 may be silver or nickel. The sealant 14 may have a low viscosity in the liquid state allowing good seals with small clearances between the fibre 12 and component 11. The sealant 14 may have a low vapour pressure so that the seal does not offer an inherent source of contamination to a vacuum or other gaseous environment. The sealant 14 may have a degree of plasticity such that small changes in the dimensions between the parts due to thermal expansion can be accommodated without compromising the seal.

FIGURE 1

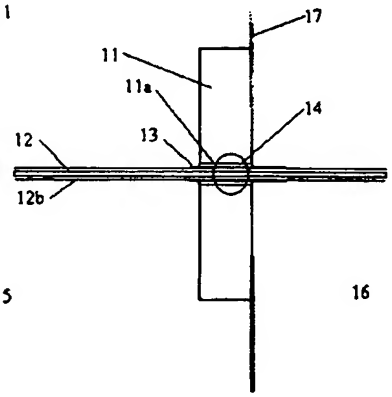

FIGURE 2

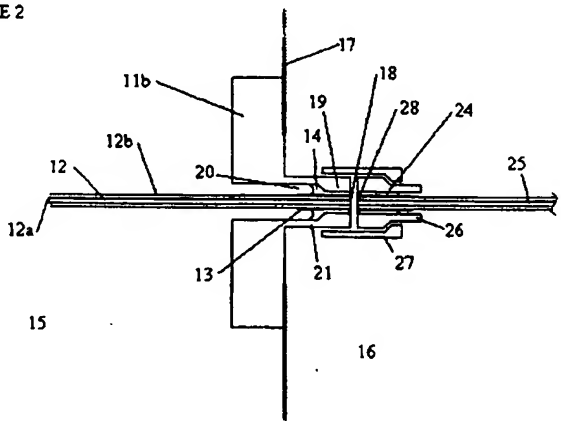

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FIGURE 1

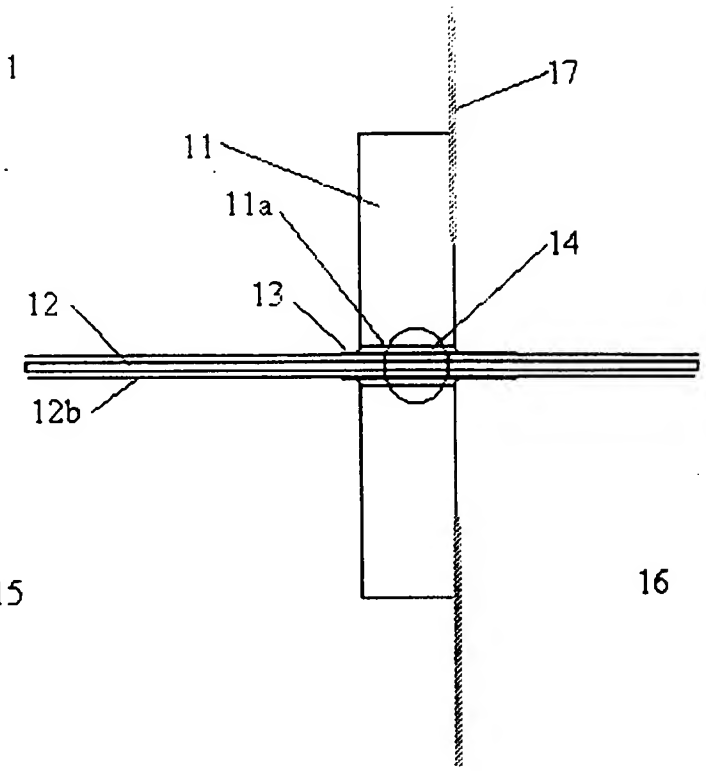


FIGURE 1A

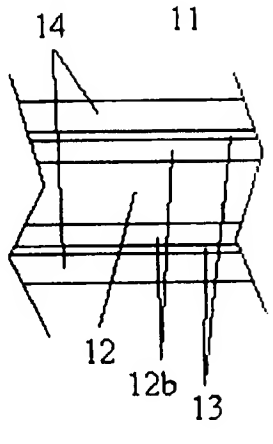
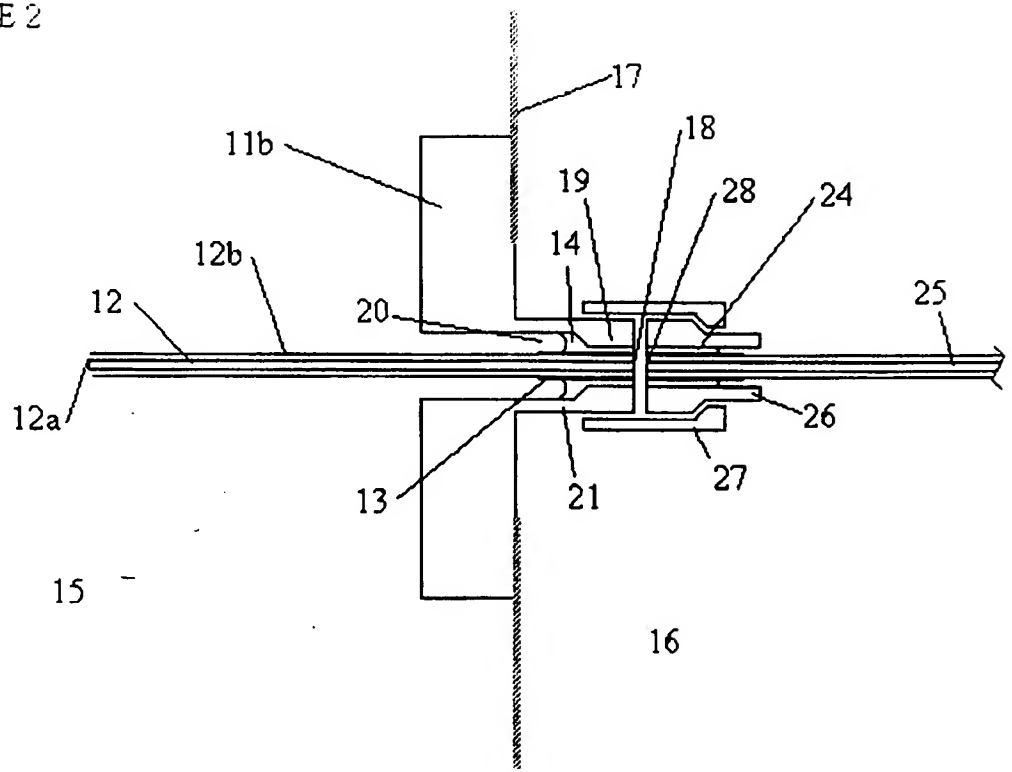


FIGURE 2



FIBRE OPTIC SEALING METHOD

This invention relates to a seal for optical fibre.

In many reaction and containment vessels, e.g. vacuum or pressure vessels, chemical reactors, etc., it is desirable to have a path for transmitting light into or out of the vessel for monitoring or similar purposes without compromising the containment offered by the vessel. Typically the path is a window. Such a window will typically be made from a material which will withstand the range of environments on both sides of the wall. The window material is normally bonded into a flange or similar mounting means so that an appropriate seal is achieved. In vacuum systems such as those used in semiconductor fabrication, thin film deposition and many other applications, such windows are large, fragile and expensive components. The window has a passive role in the optical path, making little of no contribution to delivering the light to the desired location. Indeed to do so in a stable reliable manner relies on the rigid coupling of the light source to an optical bench or vibration isolated table which in turn is firmly linked to the vacuum vessel within which the sample location is also tightly defined. This arrangement is widely used and is expensive. Further unless particular precautions are taken, the same window also provides a path for unwanted ambient light to enter the vacuum system. The use of optical fibre as a delivery means into vacuum systems has been addressed, however the methods are limited either in the range of conditions which they can sustain or in their ruggedness and practicality. The former methods using organic adhesives such as epoxy resins, which are mot compatible with bake out processes, the latter using brazing of metallised fibres which does not allow accurate fibre placement required for interconnection or subsequent demounting of the fibre for repair or replacement.

This patent describes a novel method for making seals of optical fibre to flanges or other components, such seals being compatible with recognised bake out procedures, providing accurate alignment and potential for demounting from the component into which the seal has been made to allow re-use of that component.

According to the present invention an optical fibre or optical fibre bundle is directed through a component which may be a flange or other interface between the ambient environment and a vacuum environment but may also be entirely enclosed within the vacuum or in any other appropriate environment in such a manner as to not only maintain the hermeticity of the vacuum system but also withstand the bake out used to enhance the degree of vacuum achieved within the system, minimise contamination of the vacuum system and provide a demountable connection for simplified assembly, maintenance and replacement in the event of component failure. This method is only suitable for sealing optical fibres which are comprised of materials which are in themselves compatible with both the conditions encountered in the vacuum environment and with the sealing materials.

Alternative embodiments of the invention will now be described by way of examples with reference to the accompanying drawings in which:-

Figure 1 shows a sectional view of a flange with fibre optic and seal;

Figure 1A shows and enlargement of a part of figure 1;

Figure 2 shows a sectional view of an alternative flange with integral connector and a mating connector.

Referring to a simple embodiment as shown in figure 1, the ultra high vacuum compatible feed through comprises of a vacuum system flange 11, typically manufactured from stainless steel, which has a capillary hole, 11a, passing through it. The optical fibre 12 is coated over some or all of its length including that region where the seal is to be made with a thin layer 13 of silver, nickel or other metallisation either directly onto the bare fibre surface or where the fibre jacket material 12b is sufficiently resilient, e.g. polyimide, and certain other metals, onto the jacket. The coating method shall achieve good adhesion between the coating 13 and either the bare fibre 12 or the jacket 12b accordingly. The metallisation shall exclude those metals, for example aluminium, which are known to react with the sealing materials at elevated temperatures. The method known as sputter coating is known to be capable of achieving the required level of adhesion of the metallisation.

The fibre 12 is located into the hole 12 from the ambient or air side 15 until the coated region 13 of the fibre extended fully through the capillary region 11a of the flange 11.

A quantity of the sealing material 14, substantially comprising of silver chloride, silver bromide or a mixture of the two compounds, is either placed into the space between the capillary region 11a and the fibre coating 13 region prior to heating or is applied when the assembled components have been raised to a temperature slightly in excess of the melting point of the sealing material.

When the sealing material 14 melts, surface tension carries the liquid sealing material through the capillary space between the coated region of the fibre 13 and the capillary 11a.

On cooling the sealing material solidifies and a hermetic bond is formed between the fibre 12 and the flange 11 with the sealing material 14 bonding intimately with both parts. The seal integrity is further maintained by the pressure applied to the fibre by the relative contraction of the flange 11 about the fibre 12 on cooling.

The structure of the seal is shown in more detail in figure 1A, which shows an enlargement of the circled region in figure 1. With the body of the flange represented by areas marked 11, the seal material by the regions marked 14, the coating by the regions marked 13, the fibre by the region marked 12 and the fibre jacked marked as 12b.

Figure 2 shows a preferred embodiment of the seal. A different flange 11b is shown which has a part 21 extending from the body of the flange which forms part of a fibre optic connector on the vacuum side 16 of the boundary or wall 17. This connector part 21 may be compatible with proprietary designs or may be of a new construction. The mating connector 26 uses a similar construction to the flange, with sealing material 24 and optical fibre 25 being treated and prepared in a similar manner to their counterparts 12 and 14 in the flange 11b. The two connectors are joined by a concentric sleeve 27. To ensure good transmission of the light

passing along the fibres the end faces 18 and 28 may be prepared in a manner known to one skilled in the art. The end of optical fibre 25 remote from the polished face 28 may lead to a location within the vacuum or low pressure environment from or to which light or other electromagnetic radiation conveyable by optical fibre is to be relayed.

Use of a connector 21 integral to the flange 11b enables easier assembly of the vacuum equipment. In particular it allows the gasket, (not shown in the figures), usually used when sealing flanges to vacuum vessel walls to be fitted without threading the entire vacuum side length of fibre through the gasket thereby minimising the risk of damage to the fibre during assembly.

An additional connector may be made integral to the ambient or higher pressure side 15 of the flange or similar assembly, however where it is intended that this side of the boundary 17 is in ambient conditions there is no need for a vacuum compatible seal and a wider range of materials known to one skilled in the art may be used.

Additional features of the embodiment of figure 2 provide both improved sealing and simplified installation, use and maintenance over the embodiment of figure 1. In particular, the capillary 19 now has a wider lead in region 20 on the ambient or high pressure side 15. This offers convenience when applying the sealing material 14 during assembly. It also enhances the seal, since the force exerted on the exposed surface of the seal 14 by the higher pressure of the environment on side 15 over that on the vacuum or low pressure side, 16, serves to push the sealing material 14 into the space between the fibre coating 13 and the capillary 19. Such a lead in region 20 is not required for the connector 26 as both sides of the seal are at the same pressure. However a vacuum compatible sealing material is still required. The relative separation of the capillary region 19 from the body of the flange means that the amount of heat required to create a seal can be decreased allowing more control over the sealing process.

Once the seal is formed it may be baked out to at least 200 degrees centigrade without degradation of performance which, in conjunction with the absence of organic materials in the assembly, results in very little degradation of the vacuum quality from such a feed through. The above named silver compounds are particularly suitable for such a seal is several respects. The inherent plasticity of these materials accommodates thermal stresses during bake out which might otherwise damage the fibre. The low viscosity of the sealing material on melting allows very small clearances to be achieved between the fibre 12 and the flange 11. The small clearances allow tight coaxial tolerances to be held between the fibre and the connector thereby maximising the optical coupling between mated fibres.

It can be seen that more than one fibre or integral connector may be sealed into a single flange or similar component, thereby offering considerable space savings over fitting of a corresponding number of windows in a vacuum vessel.

A seal similar to those described above may be made with a fused fibre bundle having integral hermeticity in place of the single fibre.

Claims

1. Fibre optic sealing means characterised in that an optical fibre is mounted into a component one function of which is to act as a boundary between two media for the purpose of making the path followed by the optical fibre hermetic.

2. A seal according to claim 1 characterised in that the seal is formed between an optical fibre and another component wherein the fibre passes directly through the other component and the seal is formed at a point on the length of the optical fibre.

3. A seal according to claim 1 characterised in that the seal is formed between an optical fibre and another component wherein the fibre ends at the other component and the seal is formed at an end of the fibre.

4. A seal according to claims 2 and 3 characterised in that the supporting component has formed into it mechanical structures compatible with recognised fibre optic connector types. E.g. the SMA connector type.

5. A seal according to claims 3 and 4 characterised in that the sealed end of the fibre can be polished or otherwise prepared to ensure optimum coupling of light into the mating components which may be used to collect light passing through the first component.

6. A seal according to claims 2 to 5 characterised in that the supporting component is constructed with a larger area of sealant presented to the medium on the side of the boundary exposed to the higher pressure.

7. A seal according to claims 2 to 6 characterised in that the supporting component is formed such that the region to which heat is applied to make the seal is thermally removed from the bulk of the material mass of the component so that a minimum quantity of heat is required to form the seal.

8. A seal according to any of the claims 1 to 7 characterised in that the seal is made between the component and the buffer layer of the optical fibre.

9. A seal according to any of the claims 1 to 7 characterised in that the seal is made between the component and the bare optical fibre.

10. A seal according to any of the claims 1 to 7 characterised in that the seal is made between a thin metallic layer on the surface of the fibre and the component.

11. A seal according to any of the claims 1 to 7 characterised in that the seal is made between a thin metallic layer on the surface of the buffer layer and the component.

12. A seal according to claims 10 and 11 characterised in that the metallic layer is substantially of silver

13. A seal according to claims 10 and 11 characterised in that the metallic layer is substantially of nickel

14. A seal according to any of the claims 1 to 13 characterised in that the sealant material has a very low viscosity while in the liquid state allowing good seals to be made with very small clearances between the fibre and component ensuring good mechanical tolerances between the component alignment features and the fibre optic.

15. A seal according to any of the claims 1 to 13 characterised in that the sealant material has a low vapour pressure thereby ensuring that the seal so formed does not offer an inherent source of contamination to a vacuum or similar gaseous environment.

16. A seal according to any of the claims 1 to 13 characterised in that the sealant material has little or no porosity in the solid state after the seal has been made to preclude leakage or outgassing into the media on either side of the boundary through which the optical fibre is directed.

17. A seal according to any of the claims 1 to 13 characterised in that the sealant material when solid has a degree of plasticity so that small changes in dimensions between the assembled parts due to thermal expansion and contraction or other reason can be accommodated without compromising the seal so formed.

18. A seal according to any of the claims 1 to 17 characterised in that the sealing material is substantially silver chloride

19. A seal according to any of the claims 1 to 17 characterised in that the sealing material is substantially silver bromide.

20. A seal according to any of the claims 1 to 17 characterised in that the sealing material is a mixture of silver chloride and silver bromide.

21. A seal according to any of the claims 1 to 20 characterised in that the component contains more than one separate seal the totality of which are all supported on one main component.

22. A seal according to any of the claims 1 to 21 characterised in that the fibre end not requiring vacuum compatibility also has a connector fitted.

23. A seal according to any of the claims 1 to 21 characterised in that the seal is entirely in the same environment on both sides but that the benefits of minimal contamination and the capability for operation at elevated temperatures are maintained

24. A seal according to any of the claims 1 to 23 characterised in that the fibre optic is a fused bundle rather than a single fibre.

25. A seal such as is described in this patent and is shown in figures 1 to 2.

Amendments to the claims have been filed as follows

Claims

1. A hermetic seal formed between two components one of which is an optical fibre the other of which forms a part of the boundary between two media to be separated wherein the seal may be made either at the end of or at a point along the length of said optical fibre which may have metallisation applied either to its jacket or directly to the bare fibre such metallisation which may be either silver or nickel or other suitable metal characterised in that the material used to form the seal comprises of silver chloride or silver bromide or a mixture of these two compounds.

2. A seal described in claim 1 in which the seal is made at the end of the optical fibre and said optical fibre end can be polished or otherwise prepared to ensure optimum coupling of light into such mating components as may be used to collect light passing through the said optical fibre.

3. A seal described in claim 1 or claim 2 characterised in that the component forming a part of the boundary between two media has formed into it structures compatible with recognised fibre optic connector types e.g. the SMA connector type for the purposes of simplified mating with the sealed optical fibre.

4. A seal described on any of claims 1 to 3 characterised in that the component which forms part of a boundary between two media is constructed with a the area of the seal presented to the medium on the side of the boundary exposed to the higher pressure being larger than the area of the seal presented to the medium on the lower pressure side of the boundary.

5. A seal described in any of claims 1 to 4 characterised in that the component which forms a boundary between two media is constructed such that the region to which heat is applied to make the seal is thermally removed from the bulk of the material mass of the component.

6. A seal described in any of the claims 1 to 5 characterised in that the component which forms a boundary between two media contains more than one separate optical fibre the totality of which are all supported on and hermetically sealed into the one component which forms a boundary between two media.

7. A seal described in any of the claims 1 to 6 characterised in that the optical fibre is a fused optical bundle.

8. A seal described in any of the claims 1 to 7 characterised in that a fibre end not forming a part of the seal may have a connector fitted.

9. A seal as is described in this application and is shown in figures 1 to 2.

The Patent Office

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Application No: GB 9601276.0 **Examiner:** Richard Nicholls
Claims searched: 1-25 **Date of search:** 10 March 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G2J (JGEA)

Int Cl (Ed.6): G02B

Other: Online : WPI, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 1574955 A	(WESTERN ELECTRIC) see especially figures 4 - 6	1 at least
X	EP 608895 A1	(NEC) see especially figures 3,4,7 and 8	1 at least
X	EP 383511 A2	(STC) see especially figures 1,2,4 and 6	1 at least
X	EP 125795 A1	(BT) see especially figure 2a	1 at least
X	WO 86/06472 A1	(AT&T) see especially figures 1-3	1 at least
X	US 4779788 A	(SEL) see especially figures 1,2,4,5 and 6	1 at least
X	US 4413881 A	(NTL) see especially figure 5 and column 3 lines 24-30	1 at least
X	US 4296996 A	(NIIRO) see especially figures 1a,2a and 3a particularly metal film 2	1 at least
X	US 3825320 A	(REDFERN) see especially figure 2 particularly cap members 20 and 21	1 at least
X	Research disclosure July 1990 No. 31592 (ANON)		1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.